4.4 Consideration Of The CBP Component Apparent Beyond The Limits Of Suspended Solids Above Background Conditions

Throughout the development of the Continuous Backscatter Profiling technique for observing the location of the plume, it has become apparent that there is a non-sediment component which is both visible at the surface and recorded by the ADCP™. This has been tracked for up to 3.5-4.0 km from the dredger using the CBP and is alleged to be visible from aircraft over greater distances. Composite Figure 4.2.2.9 clearly displays this, both with the CBP transects and the three depth image plots.

Early progress and technical reports prepared during the course of this project considered that such additional scatterers observable by the ADCP™ (Hitchcock & Dearnaley, 1995) could be of biological or chemical origins. The possibilities of continued aeration at these distances is considered unlikely.

Herein, we present the hypothesis that much of the scatterers and visual particles are derived from the disintegration of benthic invertebrate organic tissue matter during the dredging process.

Table 4.4 (below) presents data for the biomass of benthic macrofauna recorded from coastal sediments in UK waters in areas of potential aggregate extraction. Up to 70 samples of 25-30kg sediment each were obtained from 50 stations using a $0.2m^2$ Hamon Grab. The data are expressed as the mean values of ash free dry weight (AFDW) in grammes and has been calculated from blotted wet weight using conversion factors from Eleftheriou & Basford (1989).

The AFDW represents the materials from the tissues: the conversion factors take into account the non-tissue components such as the shells of molluscs *etc.* and principally comprise proteins, carbohydrates and lipids. It is considered likely that these form the bulk of the scatterers observed by CBP.

By way of an example, we may estimate the following order of magnitude for the quantity of organic material returned overboard during a dredging operation.

Assuming a Hamon Grab sample of 30kg is representative for the sample results presented in Table 4.4, we can derive an *in situ* AFDW as follows;

from Table 4.4:
in situ AFDW is 3.9g +/- 1.6g per $0.2m^2$
= 3.9g per 30kg AFDW
= 19.5g per m^2
= 130ppm AFDW

From Section 4, we know that during screening a 4500 tonne dredger may typically return overboard some 8000 tonnes of sediment via the reject chute and spillways.

from Section 4.1 (sediments);
losses from screening & overspill = 8000 tonnes
therefore organic matter released during loading of screened 4500 tonne cargo is;
(3.9g x 30kg/1000kg) x 8000t AFDW
= 1036.5kg
= 1.04 tonnes AFDW organic matter derived from benthic invertebrates

Expressing this as a concentration (from the known volume of water rejected);

from Section 4.1 (water);
losses from screening & overspill = 35000 tonnes
therefore 35000t water contains 1.036t AFDW
therefore 1kg water (=1 litre) contains
(1.036/35000) AFDW / litre
= 0.0296g/litre
= approximately 30mg/l

That is to say, the concentration of AFDW in the outflow from the dredger may be approximately 30mg/l, and during the loading of a screened cargo some 1.04 tonnes of broken up biomass may be discharged. This organic matter then disperses with time (at a slower rate than the sediments), and hence is visible by the ADCP™.

This figure assumes that all the invertebrates disturbed are fragmented. Lees *et al*, (1992) reported the condition of invertebrates captured using a 5mm mesh within the spillways, and concluded that a proportion of individuals appeared unharmed. It is expected that sampling with finer mesh may reveal a higher mass of constituent body parts, if not whole individuals. However, within the range of values for AFDW in the sediment samples, the value of 30mg/l is acceptable.

Comparison with data for detritus-rich environments suggests that such enrichment is significant. For example, Seiderer & Newell (1985) analysed kelp bed seawater and recorded 300-400µg.C.litre^{-1} and 46-71µg.N.litre^{-1}. Mann (1982) has established the conversion rate 10g.C.per m^2 corresponds to approximately 26g AFDW per m^2. Therefore, the detritus load of kelp bed seawater may be determined as 0.780-1.040mg/l AFDW.

Site	Mean AFDW per 0.2m^2	+/- 1 SD
Lowestoft, Norfolk	4.4	
Isle of Wight	5.59	8.97
Folkestone, Kent	4.95	23.55
Orford Ness, Suffolk	3.18	3.49
Lowestoft, Norfolk	1.49	3.49
MEAN for all sites	3.9	1.6

Table 4.4 *Biomass of benthic macrofauna recorded for coastal sediments within potential aggregate extraction sites within the UK. Data are expressed as ash-free dry weight (AFDW) in grammes per 0.2m^2 Hamon Grab sample (modified from Kenny & Rees, 1996; Newell & Seiderer, 1997a,b,c)*

Consequently, it can be seen that the enhancement of the detritus load of the overspill/reject mixtures is of the order 30 times greater than that of a rich kelp bed community. The Mean Annual Biomass for phytoplankton in the English Channel is 4g/m^2 dry weight (Harvey, 1950 *In:* Tait, 1980).

The release of significant quantities of such material into the water column is likely to significantly enhance secondary production surrounding dredged areas, a phenomenon which has been reported elsewhere (*see, for example,* Poiner & Kennedy, 1984).

Further, the specific gravity of seawater is usually within the range 1.024 - 1.028. Organic material varies from less than 1.000 to approximately 1.200. The overall density of much of the zooplankton is usually within the range 1.040 with fish tissues about 1.070. The specific gravity of many fats and oils within pelagic organisms is about 0.91 (Tait, 1980). Conversely, the specific gravity of sediment particles, many of which are quartz silica or calcium carbonate is in the range 2.300 to 2.700. The greater the (positive) density difference between the seawater and the settling particles, the faster the particles will settle.

In summary, the admixture of fats, lipids and carbohydrates may well account for the visible non-sediment component of plumes associated with marine aggregate dredging which has been observed repeatedly during this project (*see* Sections 4.3.2 & 4.3.3). The interaction of the of fats, lipids and carbohydrates with sediments is not known at this stage. Further, the consequential effect on sediment buoyancy is unclear, and hindrance of the settling of very fine (<20µm) sediments may give rise to the extended visual surface colour to the plume observed many times.

It is therefore considered of prime importance to obtain data on the AFDW and biochemical composition of the plume waters. This is quite simply performed, and would enable confirmation, or rejection, of this important conjecture. Authoritative explanation of the (aesthetically) major component of the surface plume is sorely needed.

The follow up investigation to this section is included at the end of the main report, as Annex 1.